PB-216 862

BIO-ASSAY INVESTIGATIONS, SOCONY MOBIL OIL COMPANY, BUFFALO, NEW YORK

Croswell Henderson, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1956

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BIO-ASSAY INVESTIGATIONS

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SOCONY MOBIL OIL COMPANY

BUFFALO, NEW YORK

1956

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Public Health Service

Robert A. Taft Sanitary Engineering Center

Cincinnati, Ohio

BIO-ASSAY INVESTIGATIONS

SOCONY MOBIL OIL COMPANY

BUFFALO, NEW YORK

Prepared by

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Buffalo, New York

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Introduction

Purpose

In January 1956, field studies were initiated on a cooperative basis to determine the possible effects of industrial wastes from major Buffalo River industries on the eastern end of Lake Erie and the Niagara River. Buffalo River industries cooperating in this project were National Aniline Division, Allied Chemical and Dye Corporation, Donner-Hanna Coke Corporation, and Socony-Mobil Oil Company.

This report covers an investigation of the toxicity to fish of intake waters and major effluents from the Socony-Mobil Oil Company. Refinery wastes contain some chemical compounds which are known to be toxic to aquatic life in relatively low concentration. Some of these chemicals when mixed with or

under the influence of other non-toxic components of the effluent or receiving water may exert an entirely different toxicity from that of the pure compounds. Bio-assays were made to evaluate directly the toxicity of these complex wastes.

Personnel Participating

Socony Mobile Oil Company

Carl Dubois, Technical Director

C. F. Brandt, Chief Chemist

J. H. Twist, Control Chemist

Public Health Service

Hayse H. Black, Industrial Wastes Consultant

Croswell Henderson, Biologist

H. A. Anderson, Public Health Engineer

M. W. Muszaj, Chemist

Organization of Study

The Socony Mobil Oil Company collected composite samples of the intake water and effluents to be studies. The Public Health Service conducted the bio-assays in laboratory space provided by the National Aniline Division in Buffalo. Analyses for phenols and cyanides were made in the Buffalo IJC Unit laboratory.

General Information

Refining Operations:

This oil refinery accomplishes the separation and purification of a mixed base crude, 36 to 38 gravity, received from the Illinois, Oklahoma, and East and West Texas Fields by pipe line. Processing equipment includes

single and two stage distillation units for crude fractionation, a catalytic cracking unit, a thermal reforming unit, stabilizers, or pressurized fractionating towers, caustic soda scrubbers, and a copper sweetening unit for mercaptan removal together with various other stills and equipment for product separation and purification.

The principal products of the refinery are motor gasoline, kerosene, light and heavy residual fuel oils, refined wax, light viscosity lubricating oils and asphalt. Except for periodic shut-downs of various units for inspection, general maintenance and repair, the refinery operations are on a continuous 24 hour day 7 day week basis.

Capacity and Operating Rate

The maximum capacity of this refinery is reported to be 26,000 barrels (42 gallon) of crude oil capacity per day. The operating rate during this study closely aproximated refinery capacity as shown in Table 1.

Table 1 - Operating Rate during Sampling Periods

	Operating Rate in 42-Gallon Barrels per 24 hours		
Date	Crude Oil Input	Total Feed to Catalytic Cracker	Fresh Feed to Catalytic Cracker
Jan. 23, 1956	25,200	16,300	11,300
Feb. 15, 1956	26,100	18,000	12,300
Feb. 21, 1956	26,600	15,800	10,100
June 19, 1956	26,400	15,000	10,500

Water Supply

Cooling water, obtained from the Buffalo River through two submerged shore intakes at the south edge of the refinery property, makes up more than 96 percent of the total water requirements of the refinery. Refinery

process and cooling water effluent sewers are located in the vicinity of the intakes such that recycling of the refinery effluents into the plant may frequently occur.

Process Wastes

Wastes from the refinery are segregated and discharged to the Buffalo River through three oil separators.

Thermofor Catalytic Cracking (T.C.C.) Unit Separator

The influent of this separator consists solely of river water used for indirect cooling in the catalytic cracking unit. The effluent is discharged directly to the Buffalo River.

No. 2 Reformer Separator

River water used in indirect cooling of gasoline streams of the reformer unit are discharged into this separator. Surface water with any floating oil or other substance is being continuously skimmed and sent to the master separator. The effluent is discharged to the Buffalo River.

Master Separator

All process wastes and used cooling waters, other than the above, are discharged to the master separator. Wastes from the lube oil treating and wax production departments pass through departmental separators equipped with skimming devices before discharge to the master separator. Separated water is discharged to the Buffalo River through two submerged pipes.

Waste Control Measures

In addition to oil recovery by means of gravity separators, waste control measures include reduction and breaking of emulsions; burning of sludges, mercaptans and hydrogen sulfide; and recovery of cresylic acid and sodium sulfide.

Survey Methods

Flow Measurements

Measurement of the flow of the individual refinery effluents was made on July 23. Discharges from the T.C.C. and master separator were measured with a Price Current Meter while the discharge of the No. 2 reformer separator was determined at the effluent weir by measuring the head of water over the weir. The measured total effluent flow was approximately 4.0 percent less than the total volume of plant intake water on July 23.

The effluent flows used in this report are the flows determined on July 23 adjusted proportionally according to relative volume of total plant intake water on the sampling dates to the volume of intake water on July 23. The adjustments ranged from minus 1.6 percent on January 23 and June 19 to a minus 10.0 percent on February 21.

Sampling

Samples were collected hourly and composited over an 8 hour period beginning at 8 A.M. Samples for phenol analyses were preserved with $CuSO_4$ and the samples for cyanide analyses were preserved by adding sufficient NaOH to maintain a pH of 11 or above in the sample. Ten gallon unpreserved samples were collected for bio-assays.

Chemical Methods

Analyses for cyanide and phenol were made by the methods adopted as Official Methods for Boundary Water Quality by the Board of Technical advisers to the International Joint Commission. All other determinations were made according to procedures given in "Standard Methods for the Examination of Water, Sewage, and Industrial Wastes."

Bio-assay Methods

Bio-assays were made, essentially, by the method recommended by the toxicity subcommittee of the Federation of Sewage and Industrial Wastes Associations (Sewage and Industrial Wastes, Vol. 23, No. 11, Nov. 1951). This method consists of preparing various concentrations of effluent in a selected dilution water, adding the test fish and observing their reactions over a definite time period. A logarithmic series of numbers is generally most convenient for preparing different test concentrations.

As the effluents were of unknown toxicity, exploratory or small scale tests were made to determine the approximate toxic range. Test solutions were prepared over a wide range of concentration (e.g. 100, 1, and 0.1 percent effluent). Two fish were added to 2 liters of each concentration in 6-1/2 inch diameter, 1 gallon wide mouth glass bottles. Observations for relatively short time periods indicated test concentrations necessary for the full scale experiments.

In the full scale tests, 10 fish were generally used for each test concentration. Five fish were added to 10 liter duplicate samples in 10 inch diameter, 5 gallon widemouth glass bottles. The intermediate concentrations tested were dependent upon information obtained from the exploratory tests. For example, if fish were killed in concentrations above 10 percent and not

affected in concentrations of 1 percent, intermediates were set up within this range (e.g. 10, 5.6, 3.2, 1.8, and 1.0 percent concentration of effluent).

The dilution water used was raw Lake Erie water obtained at the Buffalo, N. Y., water plant. This water was hauled into the laboratory, allowed to come to room temperature, and aerated vigorously for at least one hour to bring it to equilibrium with atmospheric gases. Characteristics of this water at time of use were as follows: Dissolved oxygen 7.6-8.2 ppm; pH 8.0-8.2; Total alkalinity ($CaCO_3$) 94-100 ppm; Total acidity ($CaCO_3$) 0-1 ppm; versenate hardness ($CaCO_3$) 120-135 ppm.

The test fish used were fathead minnows (Pimephales promelas) of a fairly uniform size, ranging in length from 2 to 2-1/2 inches and in weight from 1 to 1-1/2 grams. These fish were obtained in uniform lots from the Newtown, Ohio, Fish Hatchery and acclimated to laboratory conditions. This species is of intermediate tolerance to chemicals comparable to bass, sunfish, perch, and other warm water species, and will tolerate fairly low oxygen conditions (1-2 ppm).

Another species, the emerald shiner (Notropis atherinoides), obtained locally from a Buffalo bait dealer, was used in some experiments in order to obtain a comparison of the toxicity to fatheads and this locally abundant species.

The bio-assays were made at ordinary laboratory temperatures which were within the range from 22 to 25° C. and would compare favorably with maximum summer water temperatures in this area.

The tests were designed so that no oxygenation or aeration was generally needed. Absorption of atmospheric oxygen by the exposed water surface was normally adequate for fish requirements during the test period. However, in some of the bio-assays, high oxygen demand effluents caused oxygen depletion. When necessary, oxygen was maintained by bubbling pure oxygen through the test solution by means of a suitable arrangement of valves and small tubing. The rate (60-180 bubbles per minute) was adjusted to maintain adequate oxygen for fish survival with minimum agitation in order to prevent the loss of volatile materials.

Physical and chemical determinations (temperature, dissolved oxygen, pH, alkalinity, and hardness) were made on each concentration initially, after fish mortality, or at the completion of the test. This was done primarily to maintain control of oxygen conditions and to differentiate between fish mortality due to oxygen deficiency or acidity and toxic properties.

Fish reactions were observed over a 96 hour period. From the mortality in the different concentrations, 24, 48, and 96 hour TL_m (Median tolerance limit) values were obtained. The median tolerance limit is the concentration of effluent in dilution water that kills just 50 percent of the test fish. These values were obtained by straight line graphical interpolation from points representing percent survival of fish and log concentrations of effluents which bracketed the 50 percent point.

Effluent samples were normally brought into the laboratory in the late afternoon of the day collected. Exploratory tests were set up immediately and allowed to remain overnight. Observations the following morning indicated the toxic range and full scale tests were then set up.

Results

Physical and Chemical Characteristics

A general description and some of the chemical characteristics of the river intake water, the raster separator effluent, and the TCC effluent are shown in Table 2. The different values for some of these characteristics reflect a change in river flow but recycling of effluents into intake water is apparent.

The chemical data obtained gives little or no indication of what components in the effluents may be directly responsible for toxicity. The low dissolved oxygen values and the phenol content of the master separator effluent may be of some significance from the standpoint of the effect on aquatic life. Values for pH, alkalinity, and hardness in all effluents were within limits favorable for the support of aquatic life. Cyanides were considerably below levels expected to have an adverse effect.

TABLE 2 - SUMMARY OF PHYSICAL AND CHEMICAL DATA

SOCONY-MOBIL EFFLUENTS

Source	Date 1956	Description Color, odor, etc.	Dissolved Oxygen ppm	pH	Alkalinity ($CaCO_3$) ppm	Acidity ($CaCO_3$) ppm	Hardness ($CaCO_3$) ppm	Phenols ppb 4AA	Phenols ppb Gibbs	Cyanide ppb
River Intake Water	1-23	Light Gray Faint Gasoline Slightly turbid	8.0	7.5	140	10	215	243	234	<5
	2-15	" "	9.8	7.2	70	4	120	9	11	<5
	6-19	Brown Faint Gasoline	2.2	7.2	110	10	190	-	146	<5
Master Separator Effluent	1-23	Light Gray Gasoline Slight oil scum	0.6	7.4	140	12	200	2,953	2,306	<5
	2-15	Light Gray Strong Gasoline Turbid	1.4	7.0	72	10	135	2,252	1,966	<5
	6-19	Brownish Gray Strong Gasoline	0.0	7.2	106	14	205		1,893	<5
TCC Separator Effluent	2-21	Light Grayish Tan Faint Gasoline Clear	8.0	8.0	76	4	120	22	21	<5

Toxicity to Fish

A summary of bio-assay results showing the direct toxicity of the effluents to fish is shown in Table 3. The information on which these results are based, including concentrations tested, time for fish mortality, percent of mortality, and bio-assay control data are shown in Appendix A.

Median tolerance limit (TL_m) values were obtained for 24, 48, and 96 hour periods. The 96 hour TL_m was used to compute the dilution ratio, which is the ratio of a unit volume of effluent to dilution water which produces a 50 percent mortality of the test fish. This ratio times the effluent flow gives the dilution volume or the total flow of receiving water required to reduce the toxicity of the effluent to where a 50 percent mortality of the test fish is produced. The following formula may be used for directly computing this dilution volume:

$$\frac{100 - TL_m}{TL_m} \times \text{Effluent Flow} = \text{Dilution Volume}$$

The dilution volumes represent conditions which would cause direct injury to fish upon short time exposure and are a direct comparative measure of toxicity. Liberal application factors must be applied to these results for complete protection of aquatic life.

All of the test fish survived the 96 hour period in the undiluted river intake water and TCC effluent samples, which would indicate little or no toxicity. The master separator effluent was toxic to fish with 96 hour TL_m values for three composite samples ranging from 37 to 42 percent and dilution volumes from 29 to 36 cfs. This would indicate an effluent of reasonably uniform toxicity.

TABLE 3 - SUMMARY OF BIOASSAY DATA

SOCONY-MOBIL EFFLUENTS

Source	Date 1956	Effluent Flow cfs	TLm (Median tolerance limit) (Percent Concentration 24 hr.	48 hr.	96 hr.	Dilution Ratio	Dilution Volume cfs
Master Separator Effluent	1-23	20.9	39	37	37	1:1.70	35.6
	2-15	20.1	40	40	40	1:1.50	30.2
	6-19	20.9	45	42	42	1:1.38	28.9
	Average				40	1:1.50	31.6
T.C.C. Separator Effluent	2-21	6.2	100% Surv.	100% Surv.	100% Surv.		
River Intake Water	1-23	34.3	100% Surv.	100% Surv.	100% Surv.		
	2-15	33.1	100% Surv.	100% Surv.	100% Surv.		
	6-19	34.3	100% Surv.	100% Surv.	100% Surv.		

Significance of Data

Characteristics which may affect Aquatic Life

Refinery wastes are known to contain components which are toxic to fish. While bio-assays have shown the master separator effluent to be toxic, insufficient chemical data were available to show the major components responsible. Bio-assays could be used to trace this toxicity to process effluents.

Bio-assays conducted on phenol and ortho-cresol under experimental conditions similar to that of the effluents gave 96 hour TL_m values of 40 and 24 ppm, respectively. This would indicate that phenol was not toxic to fish at levels found in the effluent. Other phenolic compounds, especially some of the chlorophenols, have been reported toxic to fish at concentrations as low as 0.1 ppm. Sub-lethal concentrations of phenol may impart a taste to fish flesh.

The presence of an oil scum and the strong gasoline odor may be objectionable features of the master separator effluent. Oil may mix with other organic material, settle to the bottom in the form of a sludge and have an adverse effect on bottom fish food organisms. Small quantities of either oil or gasoline may impart a taste to fish flesh.

High temperatures and oxygen depleting characteristics may also have an effect on aquatic life unless adequate volumes of receiving water are available for dilution or assimilation.

Effect on Receiving waters

The master separator effluent is toxic to fish. The dilution volume necessary to reduce this toxicity to 50 percent mortality of the test fish (Table 3) would obviously not provide for complete protection of aquatic life. Liberal application factors must be used, which are based on the following major considerations:

(1) The bio-assay procedure measures 50 percent mortality during a relatively short time period in non-renewed solutions. This must be related to no effect from continuous long time exposure.

(2) Test data apply directly to the species of fish used. While fathead minnows are of intermediate tolerance and compare favorably with many warm water "game" fishes, some locally important species of fish and fish food organisms may be more sensitive. Bio-assays conducted with a locally important forage fish, the emerald shiner (Notropis atherinoides), indicated this species was approximately twice as sensitive as fathead minnows.

(3) Some effluents may vary in toxicity. A few samples may give an indication of toxicity but maximum conditions may be missed. In many situations, maximum conditions of toxicity are the limiting factor as far as aquatic life is concerned.

(4) Some conditions which may generally reduce but in some cases increase the magnitude of the application factor are the loss of volatiles, hydrolysis, oxidation, precipitation, and changes in water quality characteristics by the entrance of other effluents.

Based on the best available information an application factor of at least 3 would be necessary to prevent fish kills and as much as 10 for complete protection and propagation of fish. It is evident that low seasonal flows in the Buffalo River would not provide this necessary dilution; however, only a small portion of the Niagara River flow would be necessary.

This contribution of toxicity to the Buffalo River adds to that present from other industries in the basin. While the toxicity from individual industrial effluents is substantially reduced in the basin, enough remains to present a threat to the Niagara River under abnormal conditions. Toxicity builds up in the Buffalo River during low flows and then may be rapidly flushed into the Niagara River. Additional dilution water in the Buffalo River during low flow periods would minimize this possibility. As long as large quantities of unknown toxic materials are entering the Buffalo River basin, it cannot be stated with certainty that threat to aquatic life in the Niagara River will be completely eliminated.

The effects of temperature and oxygen depletion would no doubt be apparent in the Buffalo River at low flows as the volume of effluent exceeds that of some reported river flows. These characteristics would not significantly affect the Niagara River but may have some effect in a border zone where the Buffalo River enters Lake Erie. The presence of oils that form bottom sludges which are washed out of the Buffalo River and redeposited would be expected to have an adverse effect on bottom fish food organisms in this border zone.

Conclusions

Bio-assays have shown that the master separator effluent was toxic to fish. The toxic components were not identified. No toxicity was found in samples of Buffalo River intake water or the TCC effluent.

The master separator effluent, while among the less toxic effluents entering the Buffalo River, adds to the toxicity contributed by other industries to the basin. Seasonal low flows in the Buffalo River do not provide for adequate dilution of these wastes. Under normal flow conditions, however, little or no effect on aquatic life in the Niagara River would be expected.

The buildup of toxicity in the Buffalo River basin during low flows, with the possibility of a rapid release into the Niagara River under abnormal conditions does present some threat to aquatic life in the Niagara. Additional dilution water in the Buffalo River during low flows would minimize this possibility.

As long as large quantities of unknown toxic materials are entering the Buffalo River basin, the possibility of some effect on aquatic life in the Niagara cannot be completely eliminated. Bio-assays could be used to trace sources of toxic materials within a plant which would be of help in further reducing or eliminating the major toxic wastes.

APPENDIX TABLE A -BIOASSAY DATA
SOCONY-MOBIL OIL COMPANY
BUFFALO, NEW YORK

SOURCE AND METHOD OF COLLECTION OF SAMPLE	DATE OF COLLECTION	CONCENTRATION TESTED PERCENT	NUMBER OF TEST FISH	VOLUME OF TEST SAMPLE LITERS	TIME OF DEATH			PERCENT SURVIVAL				CHEMICAL AND PHYSICAL DATA							REMARKS
					FIRST FISH	HALF OF FISH	ALL OF FISH	24 HOURS	48 HOURS	72 HOURS	96 HOURS	TIME	TEMP. °C	DISSOLVED OXYGEN ppm.	p H	TOTAL ALK ($CaCO_3$) ppm.	TOTAL ACIDITY ($CaCO_3$) ppm	VERSENATE HARDNESS ppm.	
Master Separator	1-23-56	100										Effluent		0.6	7.4	140	12	200	LIGHT GRAY
Effluent																			GASOLINE ODOR
8-Hr.Composite		42	10	20	6 hrs	6-71 hrs.		40	30	30	30	Initial	23	5.8	7.8	116	4	150	SLIGHT OIL SCUM
7 AM - 3 PM												96 hrs.	23	4.0	7.7	124	6	200	
Fish Added		32	10	20	6 hrs.			80	70	70	70	Initial		5.0	7.6	110	6	155	
11:00 AM 1/24												96 hrs.		3.8	7.8	118	6	185	
		18	10	20	6 hrs.			90	90	90	90	Initial		6.0	7.7	104	4	145	
												96 hrs.		4.8	7.9	110	6	165	
		1	10	20				100	100	100	100	Initial		6.4	7.9	98	2	130	
												96 hrs.		4.8	7.9	108	4	150	
		Control	10	20				100	100	100	100	Initial		7.6	8.0	98	2	125	
												96 hrs.		4.4	7.8	106	4	145	
TLm (Median Tolerance Limit) - Per Cent Concentration								39	37	37	37								
Master Separator	2-15-56	100										Effluent		1.4	7.0	72	10	135	LIGHT GRAY
Effluent																			STRONG GASOLINE ODOR
8-Hr. Composite		56	2	2	2 hrs.	2 hrs.	2 hrs.						25						TURBID
7 AM - 3 PM													25						
Fish Added		42	10	20	7 hrs.	7-22 hrs.		40	40	40	40	Initial		5.8	7.5	84	4	130	24 HR. DO - 0.8
11:00 AM 2/16												96 hrs.		3.8	7.6	88	8	130	
		32	10	20				100	100	100	100	Initial		6.0	7.7	88	4	130	
												96 hrs.		3.6	7.7	92	6	130	
		18	10	20				100	100	100	100	Initial		6.6	7.9	92	2	130	
												96 hrs.		3.6	7.7	98	6	130	
		Control	10	20				100	100	100	100	Initial		7.6	8.1	96	1	125	
												96 hrs.		4.0	7.7	100	6	125	
TLm (Median Tolerance Limit) Per Cent Concentration								40	40	40	40								
Master Separator	6-19-56	100										Effluent		0	7.2	106	14	205	BROWNISH GRAY
Effluent																			STRONG GASOLINE ODOR
8-Hr Composite		56	5	10	5 hrs.	7 hrs.	48 hrs	20	0	0	0	Initial	23	4.2	7.6	100	8	165	24 HR. DO - 1.6
7 AM - 3 PM												48 hrs.	23	2.8	7.3	98	8	175	
Fish Added		32	5	10				100	100	100	100	Initial		5.4	7.8	98	6	150	24 HR. DO - 3.2
2:00 PM 6/20												96 hrs		4.2	7.6	98	6	155	
		18	5	10				100	100	100	100	Initial		6.6	8.0	98	2	140	48 HR. DO - 3.8
												96 hrs.		4.4	7.6	94	4	150	
		Control	10	20				100	100	100	100	Initial		7.8	8.2	90	0	130	
												96 hrs.		5.6	7.9	94	2	130	
TLm (Median Tolerance Limit) - Per Cent Concentration								45	42	42	42								
Oxygenated		56	5	10	5 hrs.	7-24 hrs		40	40	40	40	Initial		Same as above					48 HR. DO - 13.0
												96 hrs.		7.0	7.3	96	10	175	
		32	5	10				100	100	100	100	Initial		Same as above					48 HR. DO - 14.4
												96 hrs.		5.6	7.4				

APPENDIX TABLE A -BIOASSAY DATA

SOCONY-MOBIL OIL COMPANY
BUFFALO, NEW YORK

SOURCE AND METHOD OF COLLECTION OF SAMPLE	DATE OF COLLECTION	CONCENTRATION TESTED PERCENT	NUMBER OF TEST FISH	VOLUME OF TEST SAMPLE LITERS	TIME OF DEATH			PERCENT SURVIVAL				CHEMICAL AND PHYSICAL DATA							REMARKS
					FIRST FISH	HALF OF FISH	ALL OF FISH	24 HOURS	48 HOURS	72 HOURS	96 HOURS	TIME	TEMP. °C	DISSOLVED OXYGEN ppm.	P H	TOTAL ALK ($CaCO_3$) ppm.	TOTAL ACIDITY ($CaCO_3$) ppm	VERSENATE HARDNESS ppm.	
TCC Effluent	2-21-56	100	10	20				100	100	100	100	Initial	25	8.0	8.0	76	4	120	LIGHT GRAYISH TAN
8-Hr.Composite												96 hrs.	25	5.0	7.4	72	6	125	FAINT GASOLINE ODOR
7 AM - 3 PM		56	10	20				100	100	100	100	Initial		8.0	8.1	84	2	125	FAIRLY CLEAR
Fish Added												96 hrs.		5.6	7.6	66	4	125	
12:00 N 2/22		Control	10	20				100	100	100	100	Initial		7.8	8.1	102	2	130	
												96 hrs.		5.0	7.6	102	4	130	
		No TLm Value - 100% survival of fish																	
River Intake Water	1-23-56	100	10	20				100	100	100	100	Initial	23	8.0	7.5	140	10	215	LIGHT GRAY
												96 hrs.	23	4.6	7.8	148	4	230	FAINT GASOLINE ODOR
8-Hr.Composite		75	10	20				100	100	100	100	Initial		8.0	7.6	128	6	190	SLIGHTLY TURBID
7 AM - 3 PM												96 hrs.		4.6	7.9	134	6	210	
Fish Added		56	10	20				100	100	100	100	Initial		8.0	7.7	118	4	165	
12:00 N 1/24												96 hrs.		4.8	7.9	130	4	180	
		Control	10	20				100	100	100	100	Initial		7.6	8.0	98	2	125	
												96 hrs.		4.4	7.8	106	4	145	
		No TLm Value - 100% survival of fish																	
River Intake Water	2-15-56	100	10	20				100	100	100	100	Initial	25	9.8	7.2	70	4	120	LIGHT GRAY
												96 hrs.	25	4.8	7.6	72	4	120	FAINT GASOLINE ODOR
8-Hr.Composite		56	10	20				100	100	100	100	Initial		8.4	7.5	82	2	120	SLIGHTLY TURBID
7 AM - 3 PM												96 hrs.		4.8	7.7	84	4	120	
Fish Added		Control	10	20				100	100	100	100	Initial		7.6	8.1	96	1	125	
11:00 AM 2/16												96 hrs.		4.0	7.7	100	6	130	
		No TLm Value - 100% survival of fish																	
River Intake Water	6-19-56	100	5	10				100	100	100	100	Initial	23	2.2	7.2	110	10	190	BROWN
												96 hrs.	23	4.2	7.7	110	6	210	FAINT GASOLINE ODOR
8-Hr.Composite		56	10	20				100	100	100	100	Initial		4.8	7.4	100	8	160	24-Hr.DO - 2.4
7 AM - 3 PM												96 hrs.		5.0	7.8	102	4	155	48-Hr.DO - 4.4
Fish Added		32	10	20				100	100	100	100	Initial		6.4	7.7	92	6	155	
5:00 PM 6-19												96 hrs.		4.2	7.8	100	4	150	
		Control	10	20				100	100	100	100	Initial		7.8	8.2	90	0	130	
												96 hrs.		5.8	7.9	94	2	130	
		No TLm Value - 100% survival of fish																	
Oxygenated		100	5	10				100	100	100	100	Initial		Same as above					48-Hr. DO - 18.6
												96 hrs.		6.4	7.7				

18